2// Differentiate between intensive and extensive properties. [Prev. 2nd se 2018-

→ Thermodynamic properties are classified into two types

① Intensive Properties :-

→ Intensive properties are those that are independent of the mass of the system.

Ex :- Temperature, pressure and density.

→ Lower case letters are used to denote intensive properties (with pressure P and temperature T being the obvious exceptions)

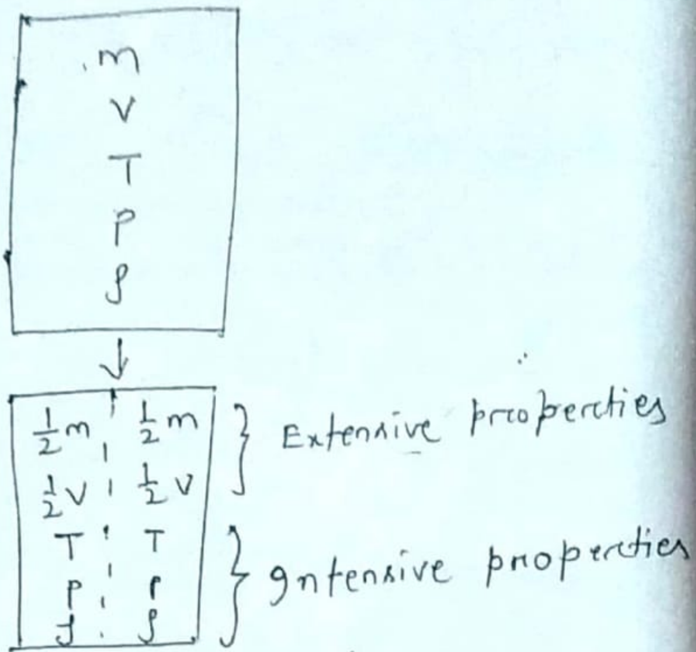
(2) Extensive Properties :-

→ Extensive properties are those whose values depend on mass of the system.

Ex :- Total mass, Total volume, Total momentum

Entropy Enthalpy

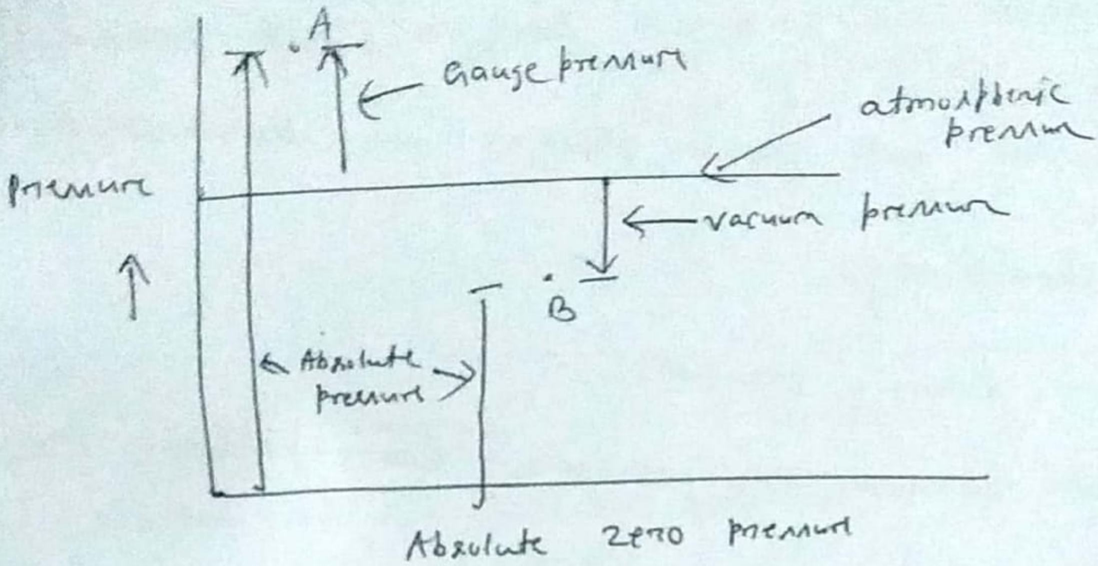
→ Generally, uppercase letters are use to denote extensive properties (with mass being a major exception).



→ An easy way to determine whether a property is intensive or extensive to divide the system into two equal pa with an imaginary partition as show in the above figure. Each part will hav the same value of intensive properties a the original system, but half the valu the extensive properties

Q11 Differentiate between absolute, gauge and vacuum pressure.

Absolute, Gauge, atmospheric and vacuum pressures



→ The pressure on a fluid is measured in two different systems. In one system, it is measured above the absolute zero or complete vacuum and it is called the absolute pressure and in other system, pressure is measured above the atmospheric pressure and it is called gauge pressure. Thus:

1. Absolute pressure is defined as the pressure which is measured with reference to absolute vacuum pressure.

2. Gauge pressure is defined as the pressure which is measured with the help of a pressure measuring instrument in which the atmospheric pressure is taken as datum. The atmospheric pressure on the scale is marked as zero.

3. Vacuum pressure is defined as the pressure below the atmospheric pressure.

The relationship between the absolute pressure, gauge pressure and vacuum pressure are shown in the figure.

Mathematically:

(i) Absolute pressure

= Atmospheric pressure + Gauge pressure.

or $P_{ab} = P_{atm} + P_{gauge}$

(ii) Vacuum pressure

= Atmospheric pressure – Absolute pressure

* (i) The atmospheric pressure at sea level at 15°C is 101.3 kN/m² or 10.13 N/cm² in SI unit. In case of MKS unit, it is equal to 10.033 kgf/cm²

(ii) The atmospheric pressure head is 760 mm of mercury or 10.33 m of water.

Q11 Write short notes on pressure measuring devices why U-tube manometer is used? compare with inverted type U-tube manometer with mathematical expressions. [BPUT 1st sem 2018-19]

Measurement of pressure

The pressure of a fluid is measured by the following devices.

1. Manometers 2- Mechanical gauges.

Manometers: ← Manometers are defined as the devices used for measuring the pressure at a point in a fluid by balancing the column of fluid by the same or another column of the fluid. They are classified as

(a) simple manometers (b) Differential manometers.

Mechanical gauges — These are defined as the devices used for measuring the pressure by balancing the fluid column by the spring or dead weight. The commonly used mechanical pressure gauges are

(a) Diaphragm pressure gauge (b) Bourdon tube pressure gauge

(c) Dead-weight pressure gauge (d) Bellows pressure gauge.

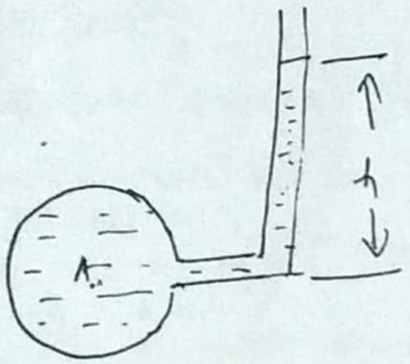
Simple manometers

A simple manometer consists of a glass tube having one of its ends connected to a point where pressure is to be measured and other end remains open to atmosphere

Common types of simple manometers are:

1. Piezometer
2. U-tube Manometer, and
3. Single column Manometer

Piezometer



(Piezometer)

→ It is the simplest form of manometer used for measuring gauge pressures. One end of this manometer is connected to the point where pressure is to be measured and other end is open to the atmosphere as shown in the figure.

→ The rise of liquid gives the pressure head at that point.

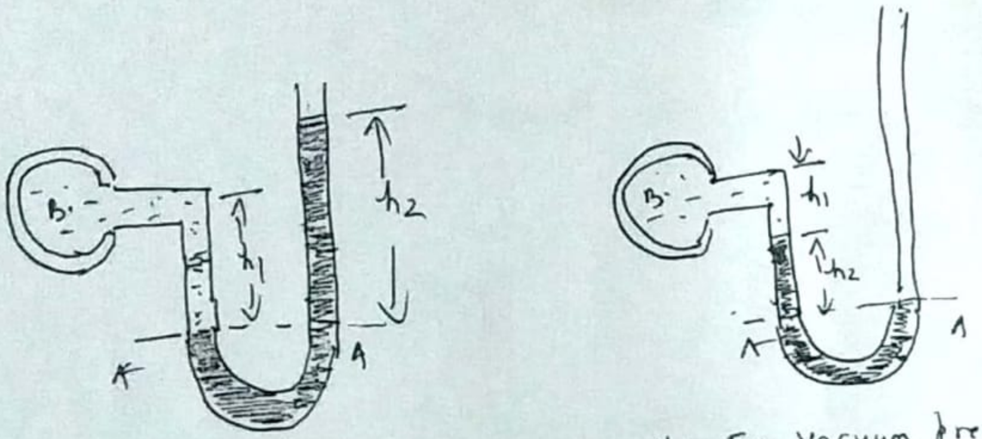
→ If at a point A, the height of liquid say water is 'h' in piezometer tube, then pressure at A

$$= \rho \times g \times h \ \frac{N}{m^2}$$

U-tube Monometer

→ It consists of glass tube bent in U-shape, one end of which is connected to a point at which pressure is to be measured and other end remains open to the atmosphere.

→ The tube generally contains mercury or any other liquid whose specific gravity is greater than the specific gravity of the liquid whose pressure is to be measured.



(a) For gauge pressure

(b) For vacuum pressure

(a) For Gauge pressure.

Let B is the point at which pressure is to be measured, whose value is p. The datum line is A–A

Let h_1 = Height of light liquid above the datum line.

h_2 = Height of heavy liquid above the datum line.

S_1 = Sp. gr. of light liquid

ρ_1 = Density of light liquid = $1000 \times S_1$

S_2 = Sp. gr. of heavy liquid

ρ_2 = Density of heavy liquid = $1000 \times S_2$

Scanned by CamScanner

→ As the pressure is the same for the horizontal surface. Hence pressure above the horizontal datum line A-A in the left column and in the right column of U-tube manometer should be same.

⇒ pressure above A-A in the left column $= p + \rho_1 \times g \times h_1$

pressure above A-A in the right column $= \rho_2 \times g \times h_2$

→ Hence equating the two pressures $p + \rho_1 g h_1 = \rho_2 g h_2$

$$\Rightarrow p = (\rho_2 g h_2 - \rho_1 g h_1)$$

__For Vacuum pressure__

For measuring vacuum pressure, the level of the heavy liquid in the manometer will be as shown in the figure, Then

pressure above A-A in the left column $= \rho_2 g h_2 + \rho_1 g h_1 + p$

pressure head in the right column above A-A $= 0$

$$\Rightarrow \rho_2 g h_2 + \rho_1 g h_1 + p = 0$$

$$\Rightarrow p = -(\rho_2 g h_2 + \rho_1 g h_1)$$

Differential Manometers

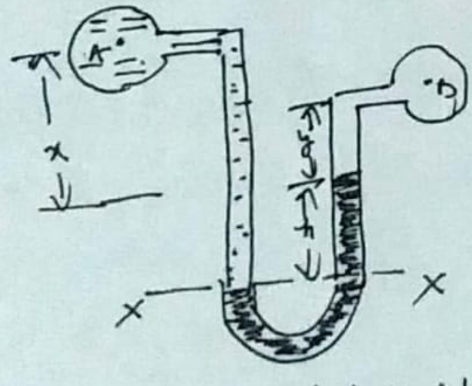
→ Differential manometers are the devices used for measuring the difference of pressures between two points in a pipe or in two different pipes.

→ A differential manometer consists of a U-tube, containing a heavy liquid, whose two ends are connected to the points whose difference of pressure is to be measured.

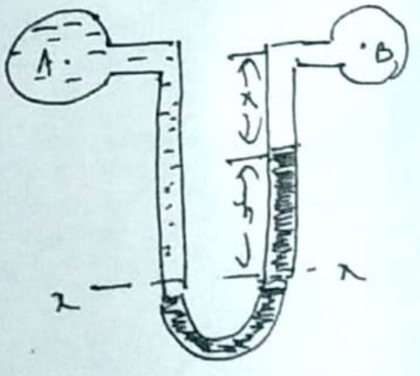
→ Most common types of differential manometers are;

1. U-tube differential manometer and
2. Inverted U-tube differential manometer.

U-tube Differential manometer.



(a) Two pipes at different levels



(b) A and B are at the same lev

Figure above shows the differential manometers of U-tube ty

In figure - ⓐ, the two points A and B are at different level and also contains liquids of different sp. gr. These points are connected to the U-tube differential manometer.

Let the pressures at A and B are p_A and p_B.

Let h = Difference of mercury level in the U-tube.

y = Distance of the centre of B, from the mercury level in the right limb.

x = Distance of the centre of A, from the mercury level in the right limb.

ρ_1 = Density of liquid at A.

ρ_2 = Density of liquid at B.

ρ_g = Density of heavy liquid or mercury

Taking datum line at $x-x$.

pressure above $x-x$ in the left limb = $\rho_1 g(h+x) + p_A$

where p_A = pressure at A.

pressure above $x-x$ in the right limb = $\rho_g \times g \times h + \rho_2 \times g \times y + p_B$

where p_B = pressure at B.

Equating the two pressures, we have

$$\rho_1 g(h+x) + P_A = \rho_g \times g \times h + \rho_2 g y + P_B$$

$$\Rightarrow P_A - P_B = \rho_g \times g \times h + \rho_2 g y - \rho_1 g (h+x)$$

$$= h \times g (\rho_g - \rho_1) + \rho_2 g y - \rho_1 g x \quad \text{—— (i)}$$

$\therefore$ Difference of pressure at A and B $= h \times g (\rho_g - \rho_1) + \rho_2 g y - \rho_1 g x$

→ In figure-(b), the two points A and B are at the same level and contains the same liquid of density ρ_1, then

pressure above x-x in right limb $= \rho_g \times g \times h + \rho_1 \times g \times x + P_B$

pressure above x-x in left limb $= \rho_1 \times g \times (h+x) + P_A$

Equating the two pressures

$$\rho_g \times g \times h + \rho_1 g x + P_B = \rho_1 \times g \times (h+x) + P_A$$

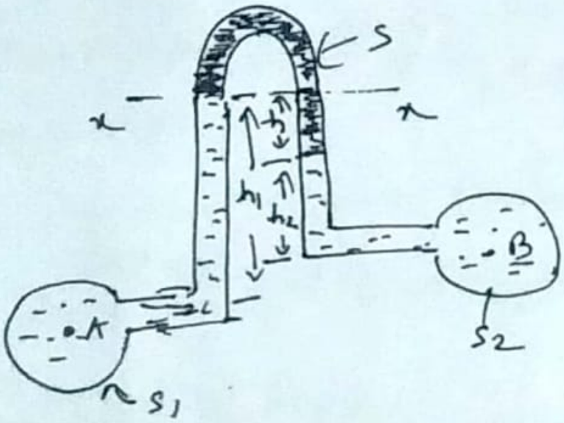
$$\Rightarrow P_A - P_B = \rho_g \times g \times h + \rho_1 g x - \rho_1 g (h+x)$$

$$= g \times h (\rho_g - \rho_1) \quad \text{———— (ii)}$$

Inverted U-tube Differential Manometer :-

It consists of an inverted U-tube, containing a light liquid. The two ends of the tube are connected to the points whose difference of pressure is to be measured.

→ It is used for measuring difference of low pressure.



→ Figure above shows an inverted U-tube differential manometer connected to the two points A and B. Let the pressure at A is more than the pressure at B.

Let h_1 = Height of liquid in left limb below the datum line x-x

h_2 = Height of liquid in right limb.

h = Difference of light liquid

ρ_1 = Density of liquid at A

ρ_2 = Density of liquid at B

ρ_s = Density of light liquid

p_A = pressure at A

p_B = pressure at B

Taking x–x as datum line. Then pressure in the left limb below x–x $= p_A - \rho_1 \times g \times h_1$

pressure in the right limb below x–x

$$= p_B - \rho_2 \times g \times h_2 - \rho_s \times g \times h$$

Equating the two pressure

$$p_A - \rho_1 \times g \times h_1 = p_B - \rho_2 \times g \times h_2 - \rho_s \times g \times h$$

$$\Rightarrow \quad p_A - p_B = \rho_1 \times g \times h_1 - \rho_2 \times g \times h_2 - \rho_s \times g \times h$$

Practical Applications of Bernoulli's equation

→ Bernoulli's equation is applied in all problems of incompressible fluid flow where energy considerations are involved.

Q// Describe the working of venturimeter with mathematical expression.

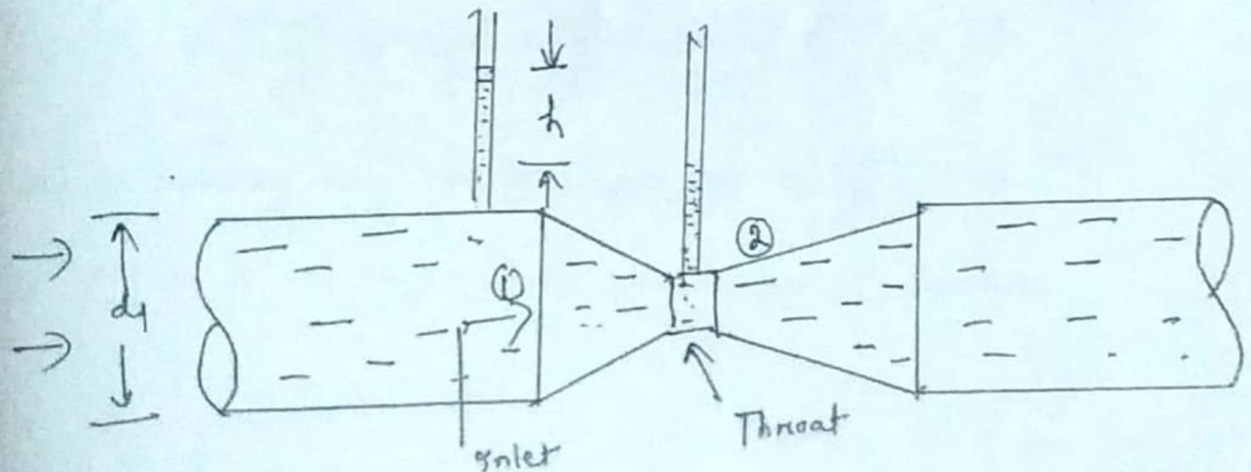
Venturimeter

→ A venturimeter is a device used for measuring the rate of a flow of a fluid flowing through a pipe. It consists of three parts.

(i) A short converging part (ii) Throat (iii) Diverging part.

It is based on the principle of Bernoulli's equation.

Expression for rate of flow through venturimeter



(figure - Venturimeter)

Consider a venturimeter fitted in a horizontal pipe through which a fluid is flowing (say water), as shown in the figure

Let d_1 = diameter at inlet or at section (1)

p_1 = pressure at section (1)

v_1 = velocity of fluid at section (1)

a = area at section (1) = $\frac{\pi}{4} d_1^2$

and d_2, p_2, v_2, a_2 are corresponding values at section (2)

Applying Bernoulli's equation at sections (1) and (2), we

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2 .$$

As pipe is horizontal, hence $z_1 = z_2$

$$\Rightarrow \frac{p_1}{\rho g} + \frac{v_1^2}{2g} = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} \Rightarrow \frac{p_1 - p_2}{\rho g} = \frac{v_2^2}{2g} - \frac{v_1^2}{2g}$$

But $\frac{p_1 - p_2}{\rho g}$ is the difference of pressure heads at sections 1 and 2 and it is equal to h or $\frac{p_1 - p_2}{\rho g} = h$

Substituting this value of $\frac{p_1 - p_2}{\rho g}$ in the above equation,

we get $h = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$

Now applying continuity equation at sections 1 and 2

$$a_1 V_1 = a_2 V_2 \Rightarrow V_1 = \frac{a_2 V_2}{a_1}$$

$$\Rightarrow h = \frac{V_2^2}{2g} - \frac{\left(\frac{a_2 V_2}{a_1}\right)^2}{2g} = \frac{V_2^2}{2g}\left[1 - \frac{a_2^2}{a_1^2}\right]$$

$$= \frac{V_2^2}{2g}\left[\frac{a_1^2 - a_2^2}{a_1^2}\right]$$

$$\Rightarrow V_2^2 = 2gh \frac{a_1^2}{a_1^2 - a_2^2}$$

$$\Rightarrow V_2 = \sqrt{2gh \frac{a_1^2}{a_1^2 - a_2^2}} = \frac{a_1}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh}$$

$\therefore$ Discharge $Q = a_2 V_2 = a_2 \frac{a_1}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$

$$= \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$$

This is equation gives the discharge under ideal condition and is called, theoritical discharge. Actual discharge will be less than theoritical discharge.

$$Q_{actual} = C_d \times \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$$

where $C_d =$ coefficient of venturimeter and its value is less than 1.